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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF AGROSTOLOGY.

[Grass and Forage Plant Investigations.]

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STUDIES

ON

AMERICAN GRASSES.

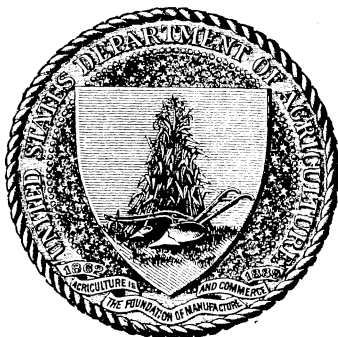
I. NEW OR LITTLE KNOWN GRASSES.

By F. LAMSON-SCHIBNER.

II. LEAF STRUCTURE OF *JOVEA* AND OF  
*ERAGROSTIS OBTUSIFLORA*.

By Miss E. L. OGDEN.

ISSUED MAY 6, 1897.



WASHINGTON:

GOVERNMENT PRINTING OFFICE.

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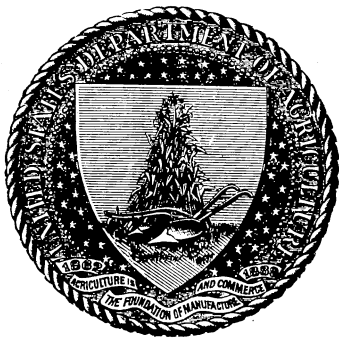
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## LETTER OF TRANSMITTAL.

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UNITED STATES DEPARTMENT OF AGRICULTURE,  
DIVISION OF AGROSTOLOGY,  
*Washington, D. C., March 18, 1897.*

SIR: I have the honor to transmit herewith and to recommend for publication as a bulletin of this Division two papers, one describing several new or little-known grasses, the second upon the Leaf Structure of *Jouvea* and of *Eragrostis obtusiflora* by the histologist of the Division. These are both technical papers, and, like Bulletin No. 4, may be entitled "Studies on American Grasses."

Respectfully,

F. LAMSON-SCRIBNER,  
*Agrostologist.*

Hon. JAMES WILSON,  
*Secretary of Agriculture.*

351092

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# STUDIES ON AMERICAN GRASSES.

## I. NEW OR LITTLE KNOWN GRASSES.

By F. LAMSON-SCRIBNER.

In the investigations being carried on necessary to the preparation of the proposed "Handbook of North American Grasses," new species or species heretofore unidentified or incorrectly determined are met with in the collections of the National Herbarium or in those submitted for examination. As the early publication of such new species and revised determinations is desirable, it has been decided to publish such matter and other investigations of purely technical character involving original research as soon as sufficient material has accumulated to warrant such publication, and for such bulletins to continue the title of "STUDIES ON AMERICAN GRASSES."

In the present bulletin are included descriptions and illustrations of a number of new or little known species of grasses, including two from Mexico, collected during the past season, one by Dr. Edward Palmer, which is probably new, and one by Mr. C. G. Pringle; and an exhaustive study of the histological characters presented by the leaves of those remarkable grasses, *Jouvea pilosa* and *Jouvea straminea*, and of the peculiar and very well marked species of *Eragrostis* which is here described under the name of *E. obtusiflora*, upon the supposition that it is the same as the *Brizopyrum obtusiflorum* of Fournier.

**Poa turneri** Scribn. sp. nov. (Plate I). A stoloniferous and apparently dioecious grass, 4 to 7 dm. high, with soft, flat leaves, and more or less spreading and nodding panicles of rather large, compressed, 3- to 6-flowered spikelets. Culms smooth, more or less geniculate at the lower nodes; nodes dark olive-green or nearly black; sheaths striate, smooth; leaf blade 10 to 15 cm. long, 5 to 6 mm. wide, acute, scabrous near the apex, and sometimes sparingly pilose on the upper surface near the base, otherwise smooth; ligule hyaline, 5 to 6 mm. long, rounded at the apex. Panicle 8 to 15 cm. long, the slender branches in threes or fives (rarely in twos), flower-bearing above the middle, naked below, the longer lower ones 5 to 10 cm. long. Spikelets about 7 mm. long, ovate, 3- to 6-flowered, glumes lanceolate, acuminate, the outer ones subequal, very acute, scarious on the margins, 3-nerved, about equaling the nearest flowering glumes; flowering glumes 5-nerved, scabrous on the keel near the acute apex, densely pilose on the keel and marginal nerves below, with a copious tuft of long, cobwebby hairs at the base, scabrous between the nerves above, more or less pubescent between the nerves below in the fertile spikelets, margins scarious; palea a little shorter than the glume, ciliate on the keel, and in the fertile spikelets pubescent between the nerves.

No. 65, L. Stejneger, Kurile Islands, August 22, 1896. Fertile plants of this species are represented in the National Herbarium by Nos. 1185, 1200, and a part of No. 1206, L. M. Turner, collected on Atka Island, Alaska, in July, 1880, reported to be common.

This species is very closely related to *P. hispidula* Vasey, but may be distinguished by its more open and lax panicle, its larger spikelets, which are usually 4- to 5-flowered, and by its longer, narrower, and more acute glumes, both the outer ones being 3-nerved and nearly or quite as long as the nearest floral glumes.

***Poa leibergii* Scribn. sp. nov.** (Plate II). A densely caespitose, fibrous-rooted, glabrous perennial, with crowded basal leaves 1 to 5 cm. long, slender, scape-like culms .5 to 1.5 dm. high, and few-flowered, simple panicles; base of the culms densely clothed with loose scarious sheaths. Innovations intravaginal. Culm leaf one, hardly appearing above the leaves of the innovations; ligule very delicate, hyaline, about 2 mm. long; leaf blade about 1 mm. wide, 2 to 4 cm. long, that of the culm 1 to 2 cm. long, conduplicate when dry, minutely scabrous along the margins and at the apex, otherwise smooth. Panicles bearing 3 to 7 spikelets, or sometimes reduced to a single spikelet. Lower branches usually in pairs, minutely scabrous, each branch bearing a single spikelet. Spikelets 2- to 3-flowered, 5 to 6 mm. long, rather broadly ovate; outer glumes somewhat unequal, the first broadly lanceolate, 1-nerved and subacute, the second much broader than the first, 3-nerved, and varying from subacute to broadly truncate at the erose-dentate apex; flowering glumes glabrous, the first 4 to 5 mm. long, somewhat exceeding the outer glumes, distinctly 5-nerved, obtuse and erose-dentate at the scarious apex; palea a little shorter than the glume, ciliate-scabrous on the keels excepting near the base.

Collected on the summits of the ridges which form the northwestern angle of the barren valley, Malheur County, Oregon—the Owyhee-Malheur Divide, altitude 1,250 m., No. 2171, John B. Leiberg, May 31, 1896.

Regarding this grass Mr. Leiberg says: "It grows in medium-sized, extremely tufted, and densely matted patches, occurring rather sparingly in open, turfy places in the Juniper timber, especially upon depressed areas which hold water during a few weeks in early summer."

This species is at once distinguished from *Poa pattersoni* by its fewer-flowered panicles and glabrous flowering glumes. The alpine *Poa lettermani* Vasey has a habit of growth somewhat similar, and glabrous flowering glumes, but the spikelets are hardly more than half as large, and the outer glumes exceed the flowering glumes in length. It does not possess the long, scape-like culm of the species here described. *Poa pringlei* is a more rigid grass, with short, creeping rootstocks, shorter culm leaves, and larger spikelets, the flowering glumes being much firmer in texture and distinctly scabrous, especially near the apex.

***Panicum leibergii* Scribn.** (Plate III). (*Panicum scoparium leibergii* Vasey, Contr. U. S. Natl. Herb., Vol. 3, 31.) (*Panicum scribnerianum leibergii* Scribn. Bull. 6, Div. Agros. 32; 1897.)—A slender, erect or ascending perennial 3 to 6 dm. high, with rather broad, flat leaves, and few-flowered panicles of comparatively large, obtuse spikelets. Culms strongly scabrous, especially near the nodes, often geniculate at the base, finally much branched, branches erect; sheaths rather loose, striate, papillate-pilose to hirsute, with rather long spreading hairs, the papillæ lying between the striæ, ciliate on the margins near the throat; ligule a very narrow and minutely ciliate ring, almost obsolete; leaf blades of the primary culms about 10 cm. long and 1.5 cm. wide (those of the branches somewhat smaller and narrower), with 9 to 11 nerves, lanceolate-acute, clasping at the rounded or subcordate base, conspicuously papillate-pilose on the lower surface, sparingly so above, rough scabrous on the upper surface and along the very narrow, cartilaginous margins, which are also more or less conspicuously ciliate. Panicle ovate-oblong, 5 to 7 cm. long, sparingly branched, the scabrous branches more or less spreading, bearing 1 to 3 spikelets. Spikelets oblong, obtuse, 3 to 4 mm. long; the outer



glumes papillate-pilose with rather stiff spreading hairs like those of the sheaths, only somewhat longer; first glume broadly ovate, subacute, 3-nerved, one-third to one-half as long as the second; second glume a little longer than the fourth, rounded, obtuse, 7- to 9-nerved; third glume similar to the second, 9-nerved, with a subhyaline palea nearly as long as itself, and usually inclosing a staminate flower; fourth or fruiting glume smooth and shining, obtuse, marked with a transverse fold or crease on the back, near the base. The panicle branches become strict with age.

Missouri, Iowa, Minnesota, South Dakota, Nebraska. The type specimens were collected by John B. Leiberger, in Plymouth County, Iowa, 1878. Other specimens in the National Herbarium are: From Minnesota, No. 3, L. R. Moyer, Chippewa County, June, 1894; Acton, Mercer County, June, 1892, collected by W. D. Frost. Iowa, No. 69 B. Shimek, May 9, 1895, Johnson County. Missouri, Nos. 730 and 744 B. F. Bush, Shannon County, May 15, 1894. Nebraska, No. 2523 Fred. Clements, Ponca, June 13, 1893. South Dakota, No. 12 Thomas A. Williams, Brookings, July, 1891, also E. N. Wilcox, No. 16, 16a, 1896. One sheet in the National Herbarium, marked "Stevens Pacific Railroad Expedition, 5 miles above Sonora," contains this species.

As in several species of the group to which this belongs, there is a smooth ring just below the nodes; below this the culms are very strongly scabrous. This species may be distinguished from *Panicum pauciflorum* Ell., by its scabrous culms, not, as in that species, more or less pubescent, by having the sheaths, leaves, and spikelets papillate-pilose; by its broader leaves and fewer-flowered and more simple panicles. *Panicum scoparium* Lam., as understood by the writer, is a much stouter plant with hairy culms, bearded nodes, and leaves softly pubescent beneath. *Panicum scribnerianum* Nash, differs from *Panicum leibergii* in having pubescent culms and more broadly ovate, glabrous, or very minutely pubescent spikelets, the first glume of which is much shorter and broader in proportion to its length.

**Elymus brownii** Scribn. & J. G. Smith, sp. nov. (Plate IV). (*Elymus mollis* R. Br., Richardson in Franklin Narr., First Voy., p. 732 [1823], not Trin.) A somewhat rigid, but rather slender, erect perennial 5 to 9 dm. high, with short cauline leaves and densely flowered spikes 4 to 10 cm. long. Rootstock creeping. Culms smooth, occasionally glaucous, and often slightly pubescent just below the nodes; sheaths striate, smooth; ligule very short, hardly 0.5 mm. long; leaf blades rather rigid, those of the innovations erect, 10 to 18 cm. long, 2 to 5 mm. wide, scabrous on the margins and nerves beneath, smooth above, very acute and somewhat pungent-pointed; cauline leaves erect or ascending, 5 to 12 cm. long, 4 to 8 mm. wide, very acute. Spikelets 3- to 6-flowered, 10 to 15 mm. long; outer glumes linear-subulate from the base, short awnpointed, nearly as long as or much shorter than the spikelets, scabrous or minutely pubescent toward the base; flowering glumes rounded on the back, densely pubescent or subvillous, short awnpointed; first flowering glume 8 to 10 mm. long; awns 2 to 4 mm long; palea nearly as long as the glume, 2-toothed, finely ciliate on the keels above.

Black Hills of South Dakota, British Columbia, and northward to Alaska. This species is represented in the National Herbarium by specimens collected by Prof. John Macoun, Bow River Pass, No. 107, September 13, 1879, also on the Saskatchewan Plains, No. 72, August 22, 1872; George W. Dawson, Dease Lake, lat. 58°, No. 103, June 23, 1887; Mr. James Macoun, Kicking Horse Lake, British Columbia, No. 43, August 16, 1890, altitude 5,000 feet and gravelly banks, Severn River, Keewatin, July 29, 1886; 1178, P. A. Rydberg, June, 1892, Elk Canyon, South Dakota; William M. Canby, Rocky Mountains, near Banff, Canada, July 19, 1895. It is from this specimen that the plate illustrating this species has been drawn. English River, Saskatchewan; there is no further data attached to this specimen.

This species is closely related to *E. dasystachys* Trin., a specimen of which, from the Botanical Museum of the Imperial Academy of St. Petersburg, is in the National Herbarium, but is easily distinguished by the outer glumes. In *E. dasystachys* Trin., the outer glumes are as long as the spikelet, distinctly flattened, and smooth and shining on the back. In *E. brownii* the outer glumes are irregular in length, usually much shorter than the spikelet, terete or subulate from the very base, and are distinctly scabrous throughout and sometimes even pubescent near the base. In the closely allied *E. junceus* Fisch., the flowering glumes are prominently nerved, while in *E. brownii* the nerves are not visible from the back.

***Elymus flavescens***, Scribner & J. G. Smith, sp., nov. (Fig. 1). A stout, erect perennial 6 to 10 dm. high, from long, creeping rootstocks, with very long, somewhat rigid leaves, and rather loosely-flowered, straw-colored spikes 10 to 20 cm. long. Culms glabrous, usually pubescent just below the nodes. Sheaths striate, glabrous, often somewhat glaucous, the lowermost becoming loose and fibrous; ligule very short, scarious, distinctly auricled; leaf blades 20 to 40 cm. long, 4 to 8 mm. wide, linear, smooth below, strongly scabrous or strigose-pubescent above, gradually tapering to the very acute, pungent tips. Spike linear or lanceolate, often branching, forming a spikelike panicle; axis and pedicels more or less silky-villous. Spikelets somewhat compressed, 3- to 6-flowered, 1 to 2 cm. long, densely villous with rather long whitish or yellowish hairs; outer glumes lanceolate or linear-lanceolate, the second usually a little broader than the first, more or less pubescent or silky-villous on the back, subaristate-pointed, about equaling the nearest flowering glume; flowering glumes broadly lanceolate, ovate, very acute, mucronate or subaristate-pointed, margins scarious, very densely silky-villous on the back with flavescent and more or less spreading hairs, which are 2 to 3 mm. long; first flowering glume about 10 to 12 mm. long; palea much narrower and about two-thirds the length of the glume, bifid at the apex, scabrous along the keel above, pubescent below the lowermost and uppermost spikelets often imperfect.

The habit of growth of this species resembles that of *Elymus arenarius*, but it is a much more slender grass, with longer, more slender spikes, which are frequently branched, becoming simple, spikelike panicles, and the spikes are conspicuous by their pale yellow or whitish color and densely silky-villous spikelets. More closely still does its habit of growth and inflorescence resemble *E. dasystachys littoralis* Griseb., but in that grass the outer glumes are glabrous and the floral glumes are pubescent, not silky-villous. In American herbaria this species has been referred to *E. mollis* Brown and to *E. dasystachys* Trin.

Dry, sandy grounds and drifting sand dunes, Idaho to Oregon and Washington, June. This species is represented in the National Herbarium by the following specimens: 916 W. N. Suksdorf, June 11, 1886, Columbus, Klickitat County, Washington; 257 E. Palmer, June 30, 1892, Blackfoot, Idaho; Thomas J. Howell, June 11, 1881, near the Dalles, Oregon, and one specimen from the Wilkes Exploring Expedition, without locality.

***Elymus dasystachys littoralis*** Griseb. in Ledeb. Flor. Ross. 4, 333. (*Elymus littoralis* Turcz.) A rather stout and somewhat rigid, erect perennial 8 to 10 dm. high from extensively creeping rootstocks, with long, pungently pointed, narrow leaves, and rather loosely flowered and often branched spikes 20 to 30 cm. long; axis pubescent. Culms glabrous, the lowermost nodes covered by loose, scarious, and sometimes bladeless sheaths. Sheaths, excepting the basal ones, strongly striate, glabrous; ligule very short, minutely ciliate, usually strongly auriculate; auricles, when present, cymbiform; leaf blades 20 to 40 cm. long, 3 to 5 mm. wide, glabrous beneath, strongly strigose-pubescent above, very long-acuminate-pointed, becoming involute. Spikelets 5- to 9-flowered, solitary, in pairs, or sometimes raised upon short branches, the spike becoming a narrow panicle. Outer glumes narrowly lanceolate, the second usually a little broader than the

first, scabrous along the keel, especially toward the rigid, subulate apex, rarely somewhat pubescent near the base, usually about one-fourth shorter than the nearest flowering glumes; flowering glumes 12 to 15 mm. long, lanceolate, very acute or subaristate-pointed, 5-nerved, margins scarious, rather densely pubescent on the back for nearly two-thirds the length, the upper third glabrous; palea nearly as long as the glume, minutely ciliate on the keels near the apex; joints of the rachilla densely pubescent.

Idaho and Washington. This species is represented in the National Herbarium by No. 466 Sandberg and Leiber, Washington, collection of 1893; No. 356 E. Palmer, collected at Idaho Falls, Idaho, July, 1893.

In habit this grass very closely

resembles *Elymus flavescens* Scribn. & Smith, having similar creeping rootstocks, long leaves and elongated, often branching spikes. It may at once be distinguished, however, by having the flowering glumes clothed merely with a short and appressed pubescence, while in *E. flavescens* the flowering glumes are densely villous with rather long, usually yellowish and spreading hairs. A grass which corresponds very well with the description of *E. dasystachys*, differing from the var. *littoralis* here described in its broader leaves, shorter spikelets, rather narrower and proportionately longer empty glumes and with flowering glumes pubescent nearly to the tips, is represented in the National Herbarium by No. 1176, W. N. Suksdorf, collected near Rockland, Klickitat County, Washington, July 3, 1890. A closely related form, evidently belonging to this species and possibly referable to var. *asper* of Regel, distinguished by its less distinctly creeping rootstocks, shorter leaves which are not strigose-pubescent above, shorter

spikes and fewer-flowered spikelets, which have the flowering glumes pubescent quite to the apex, is represented by specimens in the National Herbarium, collected at Pen Gulch, Colorado, by Prof. J. W. Letterman, August, 1885, and by Dr. George Vasey at the same locality, August, 1884. This form has some characters in common with *E. angustus*, but differs from the grass referred to that species in Bulletin No. 4, p. 38, in its awnless glumes and more rigid spikes. *E. angustus* may at once be distinguished from any form of *E. dasystachys* by its fewer-flowered spikelets, these being 2- to 3-flowered, while in *E. dasystachys* they are 4- to 9-flowered.



FIG. 1.—*Elymus flavescens* Scribn. & Smith.

A comparison of the North American species of *Elymus* of this group with types of published species or with authentically named material is greatly to be desired, and is in fact necessary to the positive identification of the species.

**Eragrostis obtusiflora** Scribn. (*Brizopyrum obtusiflorum* Fourn.?) (Plate V.) A rigid, glaucous perennial, 3 to 5 dm. high, with strong, creeping rootstocks, stiff, pungent-pointed leaves, and more or less spreading panicles 8 to 14 cm. long. Scales of the stout rootstocks closely imbricated. Sheaths striate, sparingly pilose at the throat, covering the internodes; ligule very short, ciliate; leaf blades erect-spreading, about 4 mm. wide at the base, convolute toward the cartilaginous apex, minutely scabrous above, smooth beneath. Panicle-branches erect or somewhat spreading, sharply triangular, minutely scabrous, the lower branches 5 to 7 cm. long. Spikelets 5- to 12-flowered, 7 to 15 mm. long, lanceolate, the florets rather crowded; empty glumes ovate-acute, somewhat compressed, 1-nerved, the smaller, lower one two-thirds the length of the first floret; flowering glumes broadly ovate, obtuse or subacute, rounded on the back, strongly 3-nerved, firm-membranaceous, smooth; palea broadly 2-keeled, minutely scabrous on the keels, about the length of the glume.

No. 193 Wright (collection of the Mexican Boundary Survey under Maj. W. H. Emory), on the margins of Laguna de Sta. Maria. Sulphur Springs Valley, Arizona, Prof. J. W. Toumey, September 26, 1896.

Dr. Thurber, in his manuscript notes upon the grasses of the Mexican Boundary Survey, doubtfully referred this species to *Glyceria*, but its distinctly 3-nerved flowering glumes at once separate it from that genus. The habit of growth suggests a relationship with *Distichlis* and also with *Jouvea*. The nervation of the glumes at once distinguishes it from *Distichlis*, while the character of the inflorescence and the hermaphrodite spikelets clearly separate it from *Jouvea*.

"This species is one of the most abundant grasses in the extreme alkaline portions of Sulphur Springs Valley, where the large rootstocks in many places bind the shifting sands. It rarely flowers, and its superficial appearance, without flowers, is much the same as our common salt grass (*Distichlis spicata*). It is a hard, rigid grass, but furnishes a large part of the forage of Sulphur Springs Valley, when other grasses are eaten off or are cut short by drought." (Professor Toumey.)

**Sporobolus plumbeus** (Trin.) Hemsl. (Plate VI). *Vilfa plumbea* Trin., Agrost. 1: 76, not Fourn.) A diffusely branching, leafy perennial 2 to 3 dm. high, with creeping rhizomes and spreading, rather few-flowered panicles 5 to 9 cm. long. Leaves crowded below. Sheaths loose, somewhat compressed, striate with scarios margins; ligule very short, hyaline, decurrent; leaf blades 3 to 7 cm. long, about 2 mm. wide, acute, minutely scabrous on the margins, especially near the tips, otherwise smooth. Panicle-branches more or less spreading, solitary, 1 to 5 cm. long, naked below the middle. Spikelets 3 mm. long, ovate, subacute; outer glumes subequal, rounded-obtuse, second one sometimes broadly truncate, nerveless, about half the length of the flowering glume; flowering glume broadly lanceolate, 3-nerved, subacute or submucronate pointed, minutely scabrous toward the apex; palea somewhat broader than the floral glume, about equaling it in length, minutely scabrous near the tip. Mexico, No. 6617 C. G. Pringle, 1896.

Mr. Pringle's specimens agree so nearly with Trinius, characters of his *Vilfa plumbea*, that it seems almost certain they belong to that species. I have not, however, been able to compare them with the type specimens. Trinius describes *Vilfa plumbea* as having panicles 2 inches long, the solitary branches naked below from the middle, the spikelets a line long and glabrous, with the leaves 1 to 1½ inches long and about a line wide. In Pringle's specimens the spikelets are 1½ lines long, and both the flowering glume and palea minutely scabrous toward the apex. The leaves are from 1 to 3 inches long. But this difference

in size may result from the specimens being of more vigorous growth than those seen by Trinius, and will not warrant the separation of the species without a comparison with the type.

**Muhlenbergia flaviseta** Scribn. sp. nov. (Plate VII). A slender, erect, glabrous perennial, with simple, scape-like culms 2 to 3 dm. high, short, creeping rootstocks, flat leaves which are crowded at the base, and terminal, rather densely-flowered panicles 2 to 6 cm. long. Leaves of the culm 2 to 3, hardly exceeding those of the innovations. Sheaths striate, glabrous, longer than the internodes; ligule very short, ciliate, decurrent; leaf blades 5 to 10 cm. long, the uppermost 1 to 2 cm. long, 2 to 4 mm. wide, gradually tapering from the base to the long attenuate-pointed, scabrous tips, scabrous on the margins and strongly scabrous on the upper surface. Panicle branches solitary, compound, naked below, more or less spreading in anthesis, scabrous, as are the very short pedicels. Spikelets 3 to 4 mm. long exclusive of the awns; outer glumes thin and somewhat scarious, very unequal, the first one-fourth to nearly one-half the length of the second, which is 2 to 3 mm. long, oblong-lanceolate and subacute, the apex being minutely ciliate with a few short hairs; flowering glume narrowly lanceolate, 3-nerved, minutely scabrous on the midnerve above, very shortly and minutely barbate at the base; palea a little shorter than the glume, scabrous near the acute tip. Awn yellow, 15 to 18 mm. long, arcuate or flexuose, minutely scabrous. No. 834, E. Palmer, Mexico, 1896.

This rather showy species is related to *Muhlenbergia gracilis*, from which, however, it is readily distinguished by its much more slender and scape-like culms, shorter panicle, and yellow, flexuose awns.

"This grass was found at Dos Cajetes, 30 miles nearly west from Durango, on the road to Otinapa, altitude 8,500 feet, among pines and oaks, October 23, 1896. Many plants grew together along the slopes of ravines. The color of the tops gives a very showy appearance, distinguishing the grass from everything around it. But the animals did not appear to like it, because it was noticed that none of the tops had been eaten off. It is a very abundant grass." (E. Palmer.)

## II. LEAF STRUCTURE OF JOUVEA AND OF ERAGROSTIS OBTUSIFLORA.

(Plates VIII and IX.)

By MISS E. L. OGDEN.

### JOUVEA.

Two species of the genus *Jouvea* have been distinguished—*J. pilosa* (Presl.) Scribn. and *J. straminea* Fourn. In the former species no distinction can be made in habit or in character of leaves between ♀ and ♂ plants, and to these the ♂ plant of *J. straminea* bears a close resemblance. Their leaves are rigid, closely conduplicate throughout their entire length, and terminate in a sharp, thorn-like point. The ♂ plant of *J. straminea*, which is perhaps not identified beyond the possibility of a doubt,<sup>1</sup> usually has smaller and less rigid leaves than those of the other species, yet in respect both to size and rigidity the leaves of all vary within wide limits, and render this distinction of little importance. In *J. straminea* the plants of different sex are strikingly unlike. The pistillate plant is slender with long, soft leaves that are flat for the greater part of their length and slightly involute only toward the apex.

The points of resemblance presented by plants of different species as well as the marked difference between the plants of different sex of the species *straminea* render a close examination of their structure of much interest. It is, furthermore, of much interest to compare with *Jouvea*, the leaf structure of *Eragrostis obtusiflora* (Fourn.) Scribn., a peculiar grass of the same region, which was at first suspected to be a new species of the genus in question. And since *Jouvea* itself has been referred to *Distichlis*, a comparative study is added of *D. spicata* (Linn.) Greene, as a representative of the latter genus.

These plants are all inhabitants of dry regions. *Jouvea* and *Eragrostis obtusiflora* belong to the sandy deserts of Arizona and Mexico, while *D. spicata* has a wider distribution. They may therefore be expected to show similarity in all characters of structure that are especially affected by conditions of climate and soil. At the same time plants of the same species growing under different conditions will vary much in regard to the presence and state of development of structures upon which ability to resist drought depends.

From an anatomical point of view the leaf of *Jouvea pilosa* is interesting both on account of its individual peculiarities and on account of

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<sup>1</sup> Bull. Torr. Bot. Club., Vol. XXIII, No. 4, April, 1896, Grass Notes by F. Lamson-Scribner.

the differences in structure that accompany the outward changes of form and texture from base to apex. The lower part of the blade is inclined to be involute rather than conduplicate, but the central portion is closely conduplicate when dry (probably always so) and the leaf thence tapers to a sharp, rigid, thorn-like apex.

A basal transverse section of a leaf of the ♀ plant of *J. pilosa* (fig. 1, Pl. VIII) has a slightly curved form in accordance with the involute character of the leaf at this point. The midrib differs from the other large veins only in the greater quantity of hypodermal fiber that accompanies it on the lower face. The upper face of the leaf has deep narrow furrows with rounded or nearly square ridges intervening. The lower face has no furrows but is sometimes slightly undulate.

*On the upper leaf surface* the band of epidermis covering the fibrous tissue at the summit of each ridge is composed of several rows of alternately long and short cells interrupted by numerous, thick-walled unicellular prickles. At each side of this band are several rows of cells (figs. 1 and 2, *a*, Pl. VIII) that cover the sides of the ridges and border immediately on chlorophyll-bearing parenchyma. They have numerous exodermal expansions that take the form of bluntly conical or somewhat capitate projections of some portion of the outer walls of the rectangular cells. These protuberances are often irregularly grouped around the stomata (fig. 1, *st.*, Pl. VIII) which occur in one or more longitudinal rows on each side of the ridges. Short, nearly spherical, two-celled hairs occur in the rows of cells marking the border between the first and second named bands of the epidermis. The long unicellular hairs that cover the inner surface of the leaf at its base spring from circular mound-like groups of deep and narrow colorless cells. These occur among the bulliform cells and at the margins of the leaf. Owing to the depth of the furrows, a surface view of the bulliform cells is difficult to obtain, but a transverse section (fig. 1, *B*, Pl. VIII) shows them to be in from three to five rows at the base of each furrow. The lateral ones are not distinctly different from other epidermal cells.

*On the lower surface* the epidermal cells (fig. 1, *b*, Pl. VIII) covering the bands of hypodermal fiber are narrower than those over the other tissues. They are bordered on each side by one row of cells interrupted by stomata. The epidermal cells covering the colorless cells between the veins are in several rows and are wider than those over the fiber bands. Their walls are undulate, and long and short cells alternate. In transverse section the epidermal cells of the lower face are remarkable for their large cavities. Although those covering the fiber bands are smaller than the others, yet throughout the leaf and even at the tip which consists wholly of sclerenchymatous fiber (fig. 5, Pl. VIII), the large lumina of the epidermal cells are conspicuous. Their outer walls are thickened and the surface of the leaf is very smooth and even. In the median portion of the leaf there are no exodermal expansions, but

near its base small prickle-shaped expansions and two-celled hairs occur. Stomata are numerous over the chlorophyll tissue and are unprotected. They are not all depressed below the surface of the leaf, and the guard cells are covered with cuticle that is only half as thick as that over the other epidermal cells.

The arrangement of chlorophyll-bearing cells is concentric with respect to each fibro-vascular bundle, and each bundle with its encircling rows of chlorophyll-bearing cells is entirely separated from the adjacent concentric systems by bands of colorless parenchyma that extend from the bulliform cells above to the large epidermal cells below.

The fibro-vascular bundles of the primary order have an unbroken sheath of from one to several rows of cells. The sheath cells below the bundle are often in two or more rows and have a small excentric lumen and very thick walls. The upper cells sometimes have comparatively large central cavities and thin walls, and again are like the lower cells. In the lower cells the lamination of the cell walls and the radial canals through them are conspicuous. Bundles of the secondary order (one to three of which intervene between two primary ones) have no large oval vessels and no definite line between xylem and phloëm. Their sheath is of a single row of thick-walled cells below the bundle and sometimes on the sides, but above it is replaced by a group of thin-walled, large-lumened cells, which, together with the bundle, assumes a sharply oval or pear-shaped form. In longitudinal section the length of these cells is from  $1\frac{1}{2}$  to 3 times their diameter. The transverse walls are oblique and the ends overlap. The walls are often delicately pitted. Every bundle is encircled by a ring of chlorophyll-bearing cells (fig. 1, *ch*, Pl. VIII) that are flattened on the sides next each other and toward the bundle, but are convex on the outer side of the ring. Separation of these cells by maceration proves that they are closely coherent in longitudinal rows and that the convex wall (fig. 10, *ch*, Pl. IX) is of such uneven thickness that it may be said to be either deeply pitted or reticulately thickened, while the other walls show neither pits nor reticulate markings, though they are very firm in contrast to the delicate cell walls of the rest of the chlorophyll-bearing tissue. This last, like that of nearly all grasses whose tissues have a similar concentric arrangement, is composed chiefly of cells whose long axis is parallel with that of the leaf and at least two of whose sides are marked with deep regular incisions that are opposite each other and divide the cell into regular lobes (fig. 10, *l b*, Pl. IX). The greatest width of the cell in a direction radial with respect to the bundle is several times greater than the width in a tangential direction, so that in cross section the cells seem to be radially arranged about the inner ring of pitted chlorophyll-bearing cells. This arrangement is very clearly seen in bleached sections (fig. 9, Pl. IX). The bands of colorless parenchyma (fig. 1, *c p*, Pl. VIII) between the ridges consist of one or



more rows of large, thin-walled cells which at the lower surface of the leaf expand into a width of three or four cells and at the upper surface terminate in a group of bulliform cells.

The quantity and nature of hypodermal fiber varies much in different leaves. It always occurs, however, below all bundles in one or more rows of cells and in several rows at the margin of the leaf and, except below the midnerve, is separated from the bundles by chlorophyll-bearing parenchyma. Hypodermal fiber above the bundles is represented by cells which are small in diameter and have relatively large cavities, but whose walls are firm (fig. 1, *h*, Pl. VIII). The cells next to the epidermis are usually more open, while the interior ones more nearly approach ordinary fiber in character. The diameter of these cells and the thickness of their walls vary considerably in different leaves, and sometimes the tissue approaches colorless parenchyma rather than fiber in appearance. Hypodermal fiber below the bundles and at the margins usually shows an inner cellulose layer that almost fills the cells, so that the cavity is sometimes barely distinguishable. In less rigid leaves fiber below the bundles as well as that above is of large-lumened cells, and variation in this respect is great. This is also true of the leaves of the staminate plant.

A median section (fig. 2, Pl. VIII) has the V-shape usual to conduplicate leaves (compare fig. 3, Pl. VIII). The leaf is thicker here, and the ridges are consequently higher than in the basal section. The superior epidermis and the arrangement and character of the chlorophyll tissue is the same as in the lower part of the leaf. The midrib is narrower and very acute, and the lateral ridges also assume a triangular shape. The bulliform cells are usually larger, and the bundles are all oval. In the primary bundles all the cells of the sheath, including those above the bundle, have very thick walls. Less fully developed bundles have two oval vessels, and the phloëm is separated from the chlorophyll tissue by a row of sheath cells similar to those in the largest bundles. The large-lumened, thin-walled cells are inclosed by the ring of pitted chlorophyll-bearing cells. Their number and the thickness of their walls vary with the thickness and rigidity of the leaf. The bands of colorless parenchyma between the ridges are not continuous from one face of the leaf to the other, but are interrupted by a strand of fiber (fig. 4, *h*, Pl. VIII) that is next the epidermis of the lower face and occupies the space that, in the basal section, is filled by very thin-walled, large-lumened, colorless, parenchyma cells. The thickness of this fibrous strand varies much in different leaves. It is sometimes represented by two or three small cells with slightly thickened walls, and sometimes it forms a wide band of very strong fibrous cells occupying a third of the thickness of the leaf. The character of the fibrous cells is usually more uniform in a median than in a basal section, although the cells on the upper surface still show larger cavities than those below. From the middle to the apex of the leaf the sections show successively fewer and narrower ridges,

and fibrous masses grow thicker beneath the colorless parenchyma while they decrease under the bundles. The form of the section becomes more and more closed until near the apex it assumes a palette or a circular shape (fig. 5, Pl. VIII). Here the center consists of a few large cells with scanty chlorophyll contents, but the rest is occupied by thickened cells of various sizes, all, however, with distinct lamination and conspicuous radial canals. As long as chlorophyll tissue appears near the surface, even in the thorn-like tip, stomata are to be found in the outer epidermis.

The ♂ plant of *J. straminea* does not differ much from that of *J. pilosa*, except that it is smaller and less rigid. Anatomical differences are not more pronounced. The fibrous tissue is very slightly developed; the cells are few and their walls thin, even in the strand at the margin of the leaf, and the strands under and above the bundles are reduced to one or two cells. The ♀ plant, on the other hand, is widely different from the ♂ plant of the same species. When dry, the leaves are flat except at the apex, which is somewhat involutely folded. They are less rigid than those of the staminate plant, and the apex is not pungently pointed. One or two young leaves, however, at the apex of each shoot are conduplicate, and are curved backward as in the male plant. The transverse section of one of these reveals the presence of ridges and furrows, and the bulliform cells are much smaller than those of older leaves of the same shoot. This difference is wholly due to the undeveloped condition of the bulliform cells consequent on the immaturity of the leaf. The flat leaves have usually one or two nerves of one margin folded inward for the whole length of the leaf, and it is this bend that, by bringing the margins close together, is chiefly responsible for the involute or conduplicate folding of the leaf at its apex.

A transverse section (fig. 6, Pl. IX) shows that the veins do not form ridges, but are, on the contrary, often depressed below the level of the bands of prominent bulliform cells. The veins of the basal portion of the leaf are covered for a short distance with numerous prickles. With the exception of these and of a few others sparsely scattered along the nerves and margins, the upper epidermis has no exodermal expansions proper, though the club-shaped cells that cover the chlorophyll parenchyma overlap in such a way as to make the larger end of the cell somewhat prominent. It is chiefly remarkable for the size and number of bulliform cells (fig. 6, B, Pl. IX), which are arranged in from 5 to 7 rows, the central one being very acute at the summit and very broad at the base, the lateral cells (fig. 6, b, Pl. IX) narrow and deep and projecting far beyond the stomata which border them, so that in surface view the latter are almost hidden. A longitudinal section shows that the length of the bulliform cells is never as great as their depth, and also that the underlying colorless cells are two or three times as long as the bulliform cells. Toward the apex of the leaf there are a few prickles along the nerve that marks the marginal fold; otherwise the lower epidermis

has no exodermal expansions, though its cells are less regular than those of the male plant. Bands of colorless parenchyma extend in one row of cells from the bulliform cells to the opposite face of the leaf and are never interrupted below by hypodermal fiber. Fiber is present at the margin of the leaf and there are a few fiber-cells, often only one or two, above and below each bundle. The cells are thick-walled with scarcely distinguishable cavities. The large bundles are like those of *Distichlis spicata*. They differ from those of the male plant in having not only a band of sheath cells dividing the xylem from the phloëm, but also almost invariably a band of several rows of the same cells dividing the phloëm into two parts. Also there is a sheath of one row of cells that are thick-walled around the sieve portion of the bundle, but thin-walled above the xylem.

#### ERAGROSTIS OBTUSIFLORA.

In this grass the leaves are more slender and less rigid than those of *Jouvea pilosa*, but sections from different parts of a leaf show the same variations of general form, the basal section being curved and the median V-shaped (figs. 3 and 4, Pl. VIII). The apical section differs from the median in degree only and not in form. The presence of ridges and furrows on the upper face, the shape of the bundles, and the general character of the bands of hypodermal fiber (fig. 7, Pl. IX) are like those of *Jouvea pilosa*, as is also the concentric arrangement of the tissues, and the bands of colorless parenchyma between the bundles. The lower surface of the leaf is slightly furrowed. Long pilose hairs and two-celled hairs are altogether wanting or are rare on the upper surface, but otherwise the exodermal expansions are as in *J. pilosa*. The epidermis of the lower face differs in that the cells covering colorless parenchyma are very irregular in form and in the thickness of the walls. These cells frequently have curved beak-like expansions that project over the stomata; their walls are very unevenly thickened and show many radial canals. They are frequently interrupted by glandular bodies that have a spherical hypodermal portion, a narrow neck, and a capitate exodermal portion. Similar glands occur in the superior epidermis on the sides of the ridges. The epidermal cells are all very small in transverse section. In a basal section primary and secondary bundles occur in regular alternation, but in a median section two or three secondary ones intervene between two primary. The primary bundles differ slightly from those of a corresponding section of *J. pilosa* in that a row of thickened cells separates xylem from phloëm. The secondary bundles differ in the marked line between xylem and phloëm and also in the nature of the sheath. This consists of a single row of cells. Below and above the bundle these have relatively smaller cavities and thicker walls than the corresponding cells of *J. pilosa*, but frequently on either side of the bundle there occurs one cell much larger than the others, of more angular shape, and in almost any section taken at random a transverse, pitted

wall is conspicuous. The two uppermost cells of the inner chlorophyll-bearing ring are at least twice as large as the other cells of the ring, and are usually wedge-shaped with the narrow end turned toward the bundle. They are either more liable to lose their contents in cutting or else are less abundantly filled, so that they often resemble colorless parenchyma. No large, thin-walled cells are enclosed by the chlorophyll ring, but on the other hand large groups of these cells occupy the whole summit of each ridge from one side to the other and from the round chlorophyll cells to the fiber above. The central colorless cells of each ridge are much larger than those that underlie the epidermis of the sides of the ridge and the fiber at its summit.

The cells composing the bands of hypodermal fiber show a more uniform character than those of *J. pilosa*, though the cells at the summit of the ridges generally show larger cavities than cells of the same tissue elsewhere. Its distribution is the same as in the basal section of *J. pilosa*, but the masses of this tissue below the bundles are separated from the bundle by three or four cells that form a continuous ring with the pitted chlorophyll-bearing cells, but are either entirely without contents or have only a few chlorophyll grains. The second ring of chlorophyll-bearing cells is consequently interrupted above the bundle by colorless parenchyma and below it by hypodermal fiber, and so exists simply as a band on each side of the bundle. Besides the cells arranged radially about the bundles, there are others more irregularly lobed that occur near the epidermis where it is contiguous to colorless parenchyma. Median sections do not differ much from basal sections. The ridges are more acute, and two or three secondary bundles intervene between two primary ones. The fibrous cells are a little smaller and have thicker walls, and the cells of the sheaths of the large bundles are more nearly of a uniform size and thickness. Hypodermal fiber does not (as in *J. pilosa*) occur under the colorless parenchyma between ridges.

#### DISTICHLIS SPICATA.

When dry, the leaves of *D. spicata* are involute throughout. The epidermis of the leaf shows irregularities like those of *Eragrostis obtusiflora*, but more numerous and larger, and in addition covering the fibrous tissue of the lower face. The chlorophyll-bearing parenchyma is not different from that of the other grasses. The bundle sheaths and secondary bundles resemble those of *Eragrostis obtusiflora*, but the primary bundles have the phloëm interspersed with thick-walled cells like those that separate it from the xylem; these may be in an irregular group or may form an interrupted line dividing the phloëm into two parts. Colorless parenchyma is absent except in the bands between the bundles. There is none at the summit of the ridges nor within the ring of chlorophyll-bearing cells. The fiber has the same distribution as in *Eragrostis obtusiflora*, but all the cells both above

and below the bundles and at the margin are very thick-walled, with the cavity almost obliterated by the inner thickening layer.

In all the species that we have described it will be observed that the general arrangement of the tissues is the same—that is, the chlorophyll-bearing tissues are arranged in two rings concentric with each fibro-vascular bundle, and each concentric system is separated from the next by a band of colorless parenchyma. All but *J. straminea* are deeply furrowed on the upper face, and all, either on one or on both faces, are well furnished with exodermal expansions. The furrowed leaves are either permanently closed as in *J. pilosa* and ♂ *J. straminea*, or have the power of rolling or unrolling in accordance with varying degrees of moisture. The ♀ *J. straminea* alone lacks this power, and thus shows itself less fitted for extremes of drought and heat than do the others. Bands of large thin-walled, colorless parenchyma cells are very common in grasses of dry regions. It is thought that such cells supplement those of the epidermis as storage places for water. It has also been suggested that when situated under bulliform cells they aid these to perform their function. In some cases, however, this is clearly not the actual effect; for, as in the example before us, *J. straminea*, such cells may be present in unusual size and abundance and still the leaf may prove singularly immovable. It is possible that such an arrangement aids in admitting light to the interior of the leaf, and this view is supported by the fact that the lobes of the chlorophyll cells are perpendicular to the band, just as palisade cells are perpendicular to the surface of many leaves. The advantage of additional means for utilizing light is evident when we consider that the extent of leaf surface exposed to the air is frequently reduced to a minimum in order to prevent excessive evaporation.

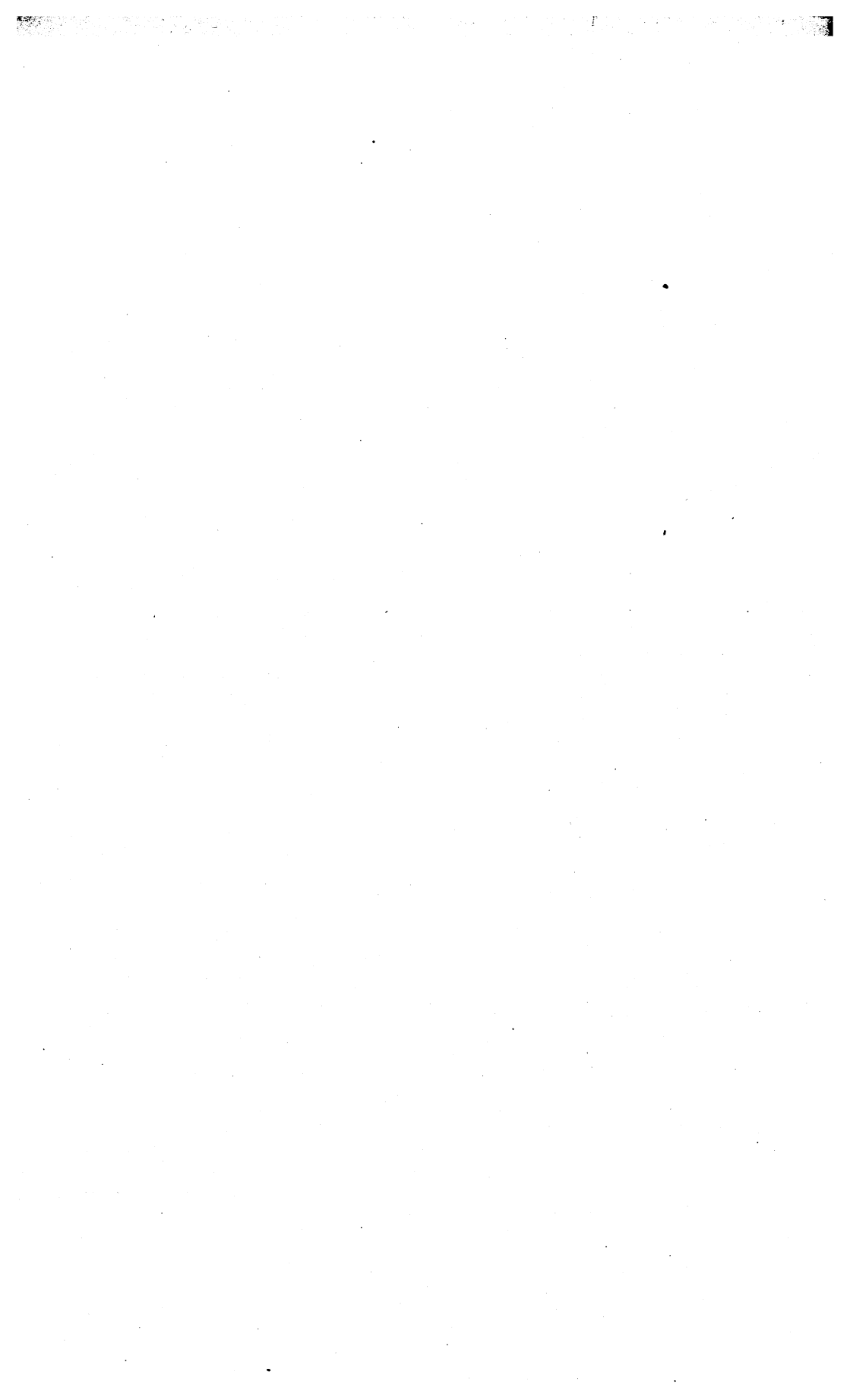
A strong development of fibrous tissue and strong bundle sheaths are common to grasses of dry regions, but it is rare that isolated strands of such tissue appear below the bands of colorless cells as in *J. pilosa*; they are usually found opposite the bundles only or form a continuous layer along the whole under surface of the leaf. It is also of rare occurrence to find so marked a difference between basal and median sections of the same leaf. The hypodermal fiber of *J. pilosa*, as we have seen, presents much variety both in quantity and in character. Its cells range from those with scarcely thickened walls to those whose cavity is almost entirely obliterated, and range from a group of a few cells only to very large, strong masses. A comparison of leaves of very rigid plants of *D. spicata* with the least rigid specimens of the same species shows that in this grass also the same thing is true of fibrous tissue. Its presence in certain positions is practically constant, but the size of the strands and the thickness of the walls of the individual cells vary much.

Although the leaves of the grasses under consideration differ from each other sufficiently to render it unlikely that necessity should arise

for distinguishing them by anatomical characters, yet it is interesting to note that in case of such a contingency separation of the species by structural peculiarities would be an easy matter. It would be of importance that the leaf to be examined should be fully developed, and if only a portion of a leaf were at hand to know whether it were basal, median, or apical. The latter question is not of vital importance, however, though where there is a choice in the matter a median section is best. The staminate plants of *J. pilosa* and *J. straminea* could not be separated by anatomical characters, but assuming as the standard a median section of a full-grown leaf of a ♀ plant of each species, the following table would serve to separate these four grasses:

Leaves unfurrowed on the upper face..... ♀ *Jouvea straminea*.  
 Leaves furrowed on the upper face.

1. Colorless parenchyma below the hypodermal fiber at the summit of the ridges,  
*Eragrostis obtusiflora*.
2. No colorless parenchyma at the summit of the ridges.
  - a. Leaf thick; inferior epidermis smooth or nearly so; fiber situated under the colorless parenchyma between the bundles.....*Jouvea pilosa*.
  - b. Leaf thin; inferior epidermis rough with numerous expansions; no strand of fiber under the colorless parenchyma between the bundles,  
*Distichlis spicata*.



## EXPLANATION OF PLATES.

- PLATE I. *Poa turneri* Scribn. *a*, empty glumes of ♀ spikelet; *b*, four florets of the same; *c*, empty glumes of ♂ spikelet; *d*, florets of the same.
- PLATE II. *Poa leibergii* Scribn. *a*, empty glumes; *b*, spikelet with the empty glumes removed; the lower figure on the left represents the flowering glume expanded.
- PLATE III. *Panicum leibergii* Scribn. *a*, spikelet showing first glume; *b*, spikelet seen from the opposite side, showing the second glume; *c*, spikelet seen from the side, showing portions of four glumes; *d*, third glume with its palea; *e*, fourth glume seen from the back; *f*, fourth glume and palea.
- PLATE IV. *Elymus brownii* Scribn. & Smith. *a*, portion of the rachis of the spike, showing two pairs of empty glumes; *b*, spikelet, empty glumes removed.
- PLATE V. *Eragrostis obtusiflora* Scribn. *a*, empty glumes of the spikelet; *b*, spikelet, the lower empty glumes removed; *c*, flowering glume expanded; *d*, lateral view of palea; *e*, portion of the rootstock.
- PLATE VI. *Sporobolus plumbens* Hemsl. *a*, spikelet; *b*, empty glumes; *c*, flowering glume and palea; *d*, caryopsis.
- PLATE VII. *Muhlenbergia flavisetata* Scribn. *a*, empty glumes; *b*, flowering glume and palea, a portion of the awn removed; *c*, second empty glume, expanded.
- PLATE VIII. Leaf structure of *Jouvea* and of *Eragrostis obtusiflora*.
- Fig. 1. Portion of a basal section of the leaf of *Jouvea pilosa*; *a*, *b*, epidermal cells.
- Fig. 2. Portion of a median section of the leaf of *Jouvea pilosa*; *a*, exodermal expansion of an epidermal cell.
- Fig. 3. Diagram of median section of the leaf of *Eragrostis obtusiflora*, showing conduplicate form.
- Fig. 4. Diagram of a transverse section of the leaf of *Eragrostis obtusiflora*, showing involute form.
- Fig. 5. Apical section of the leaf of *Jouvea pilosa*.
- PLATE IX. Leaf structure of *Jouvea*, *Eragrostis obtusiflora*, and *Distichlis spicata*.
- Fig. 6. Portion of a median section of a leaf of *Jouvea straminea*; *b*, lateral bulliform cells.
- Fig. 7. Portion of a section of a leaf of *Eragrostis obtusiflora*.
- Fig. 8. Portion of a section of a leaf of *Distichlis spicata*.
- Fig. 9. Portion of a section of a leaf of *Distichlis spicata*, bleached, showing radial arrangement of cells.
- Fig. 10. *a*, portion of longitudinal section of a leaf of *Jouvea pilosa*; *b*, isolated, lobed, assimilating cells.

In figures 1 to 9 inclusive of Plates VIII and IX the lettering is as follows:

Transverse sections: *M*, midnerve; *inf ep*, inferior epidermis; *sup ep*, superior epidermis; *B*, group of bulliform cells; *ch*, pitted chlorophyll-bearing cells; *l*, lobed chlorophyll-bearing cells; *cp*, colorless parenchyma; *x*, xylem; *ph*, phloëm; *s*, sheath of fibro-vascular bundle; *st*, stoma.

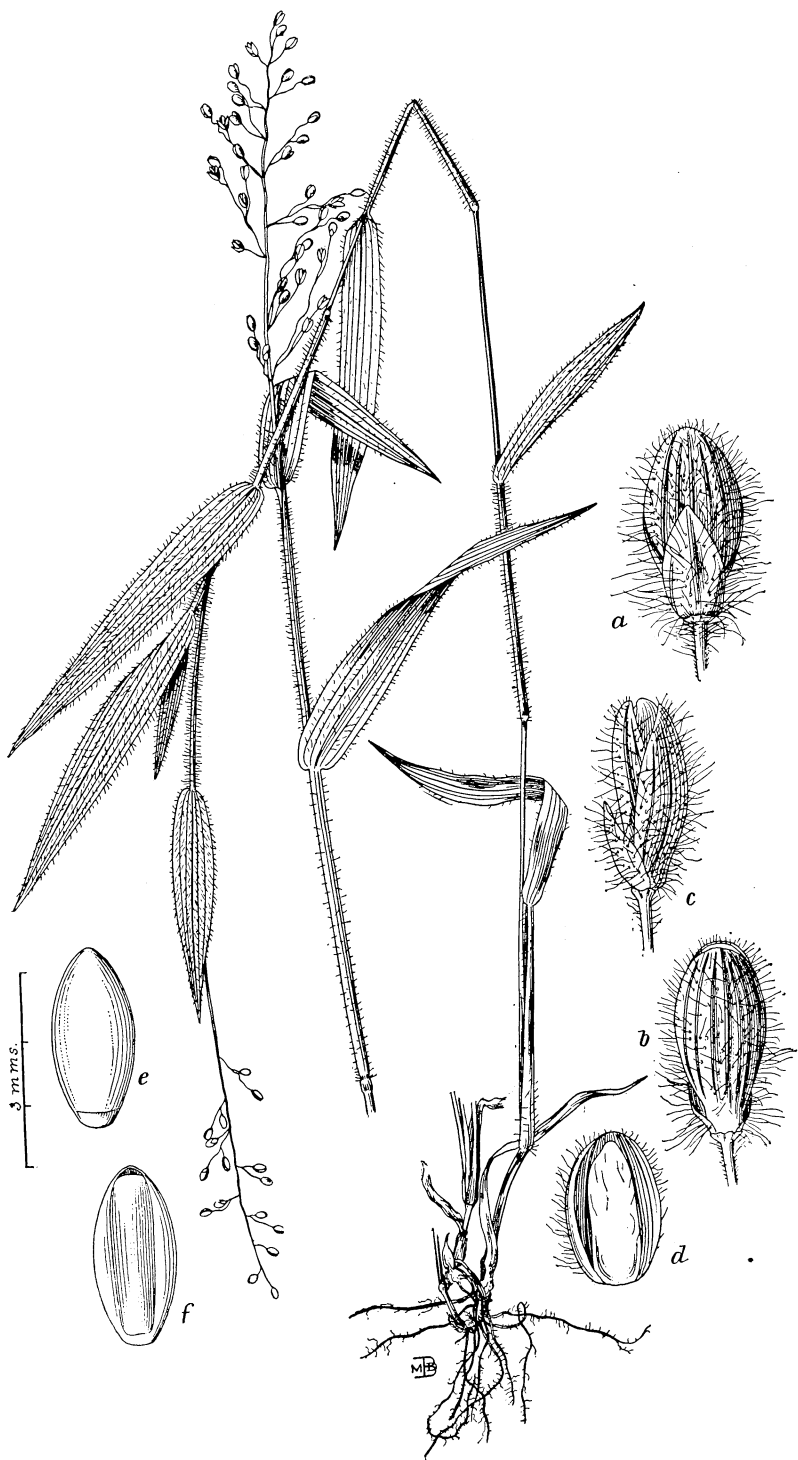




POA TURNERI Scribn.



POA LEIBERGII Scribn.



PANICUM LEIBERGII Scribn.



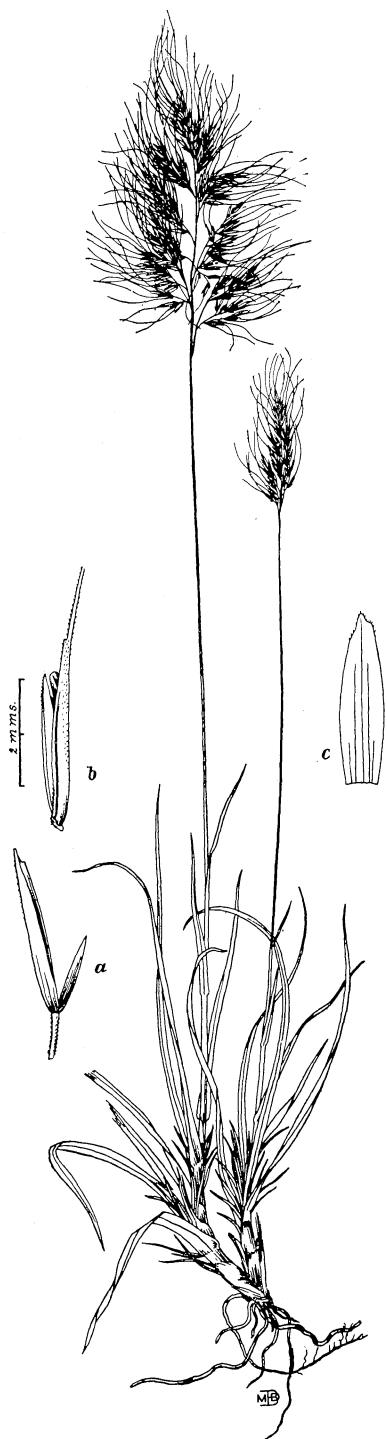
ELYMUS BROWNII Scribn. & Smith.



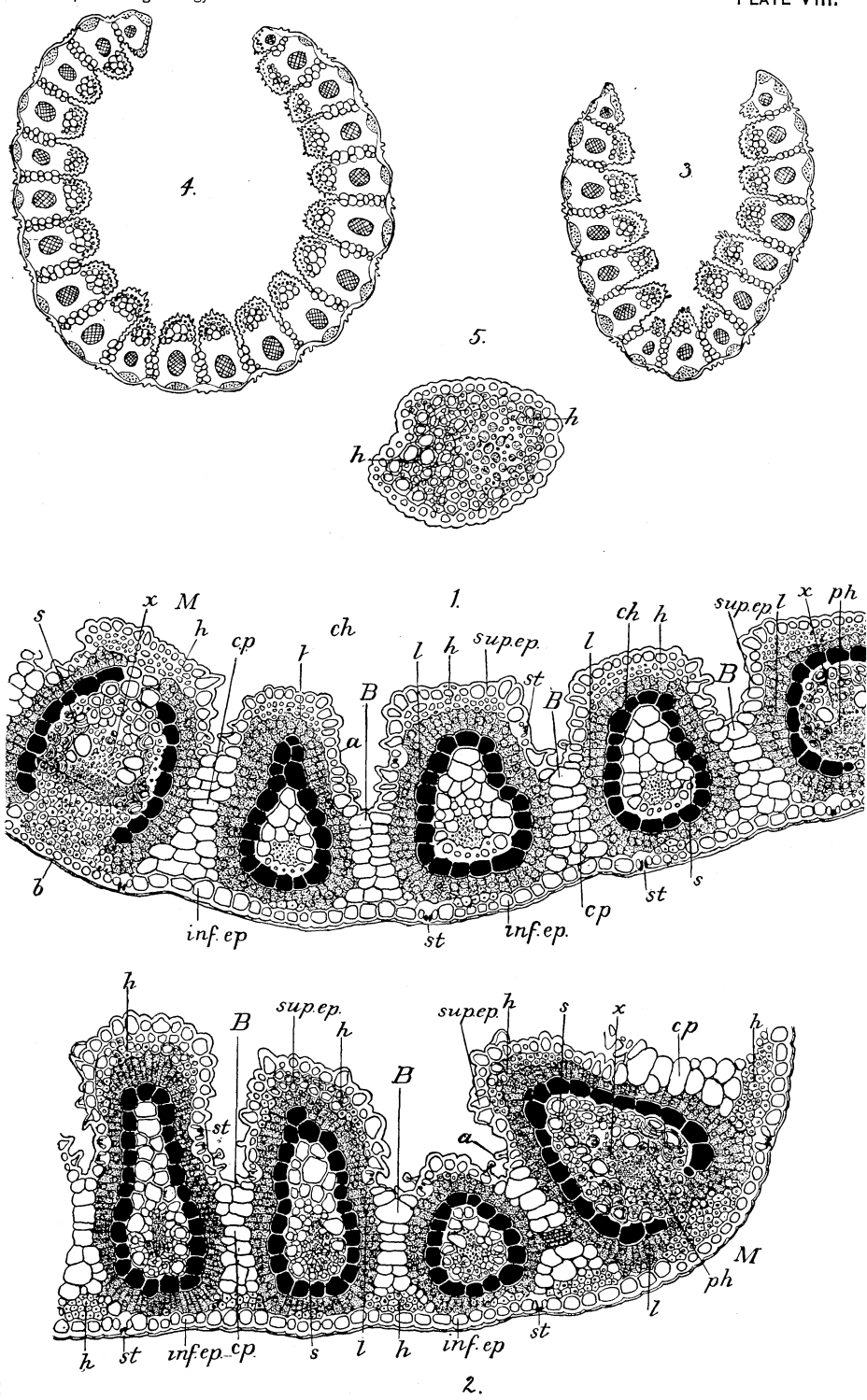
ERAGROSTIS OBTUSIFLORA Scribn.



SPOROBOLUS PLUMBEUS Hemsl.

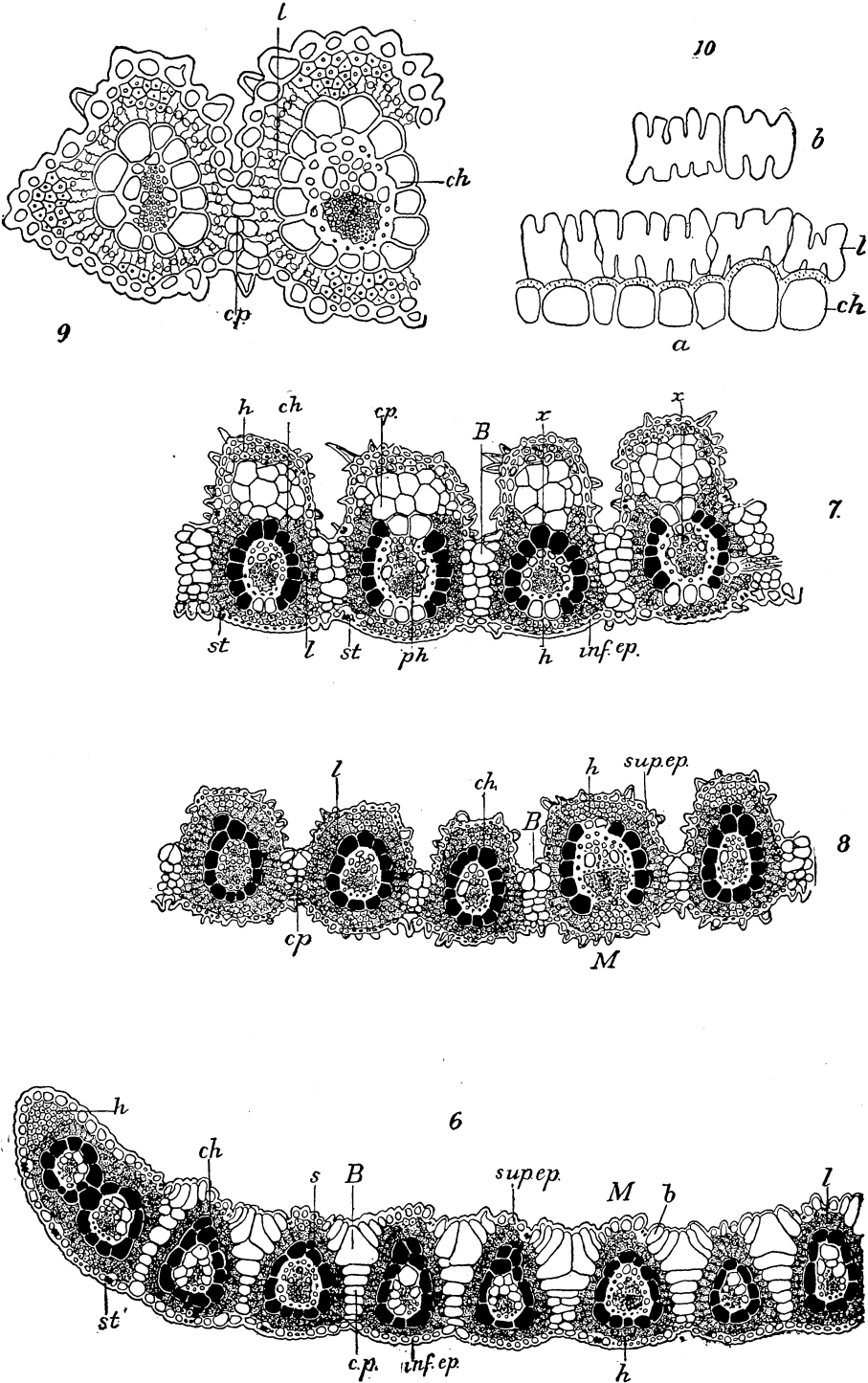


MUHLENBERGIA FLAVISETA Scribn.



LEAF STRUCTURE OF JOUEVA AND ERAGROSTIS OBTUSIFLORA.





LEAF STRUCTURE OF JOUEVA, ERAGROSTIS OBTUSIFLORA, AND DISTICHLIS SPICATA.

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